Joint Replacements

Total joint replacement are permanent implants, there are many things should be applied when using joint replacements:

- The design of an implant for joint replacement should be based on the kinematics and dynamic load transfer characteristic of the joint.
- The material properties, shape, and methods used for fixation of the implant to the patient determines the load transfer characteristics. This is one of the most important elements that determines long-term survival of the implant.
- The articulating surfaces of the joint should function with minimum friction and produce the least amount of wear products. The implant should be securely fixed to the body as early as possible.

Total Hip Replacement

The normal hip joint consists of the head of the thigh bone or a ball called (femoral head) and socket which consists of a section of your pelvis called the (acetabulum). Both are constructed of bones, the surface of each covered by a smooth layer of tissue called "cartilage" separates the ball and the socket allows the ball to glide easily inside the socket. It cushions your hip joint. Muscle and ligaments hold your hip joint in place.

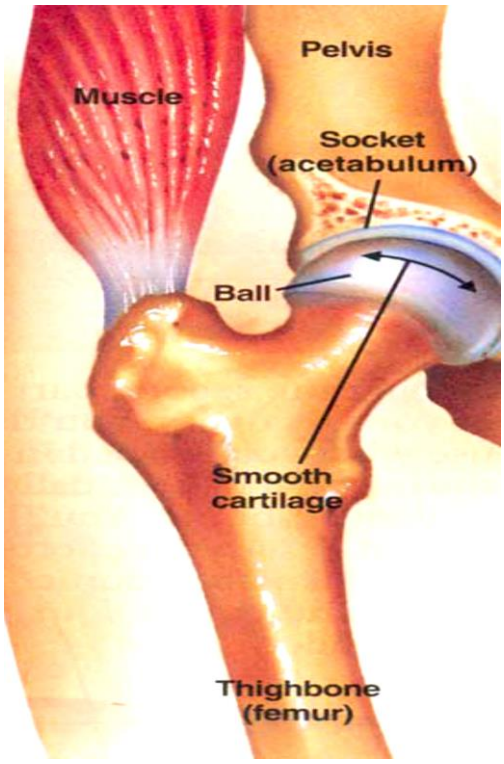

Fig 6 The normal hip joint

Sometimes, cartilage wears out. It no longer cushions the hip ball and socket. The hip joint can no longer move smoothly. As the cartilage continues to wear away, your bones rub together. The ball grinds in the socket when you move your leg. This condition causes pain. As the pain worsens and you move around less, the muscles surrounding

your joint weaken. They become less stable and less able to support your body weight. A total hip replacement can often relieve your pain and muscular instability

During total hip replacement surgery, an orthopaedic surgeon removes damaged bone and cartilage from the hip joint, and replaces them with an artificial joint. The prosthesis of total hip replacement consists of a femoral component and an acetabular component as shown in figure 7 . The femoral stem is divided into head, neck, and shaft. The femoral stem is made of Ti alloy or Co- Cr alloy (stainless steel was used earlier). The femoral head (ball) is made of Co-Cr alloy, alumina, or zirconia. The acetabular component generally made of ultra-high molecular weight polyethylene (UHMWPE). To fix the femoral stem and acetabular cup, polymethylmethacrylate (PMMA) cement was used,

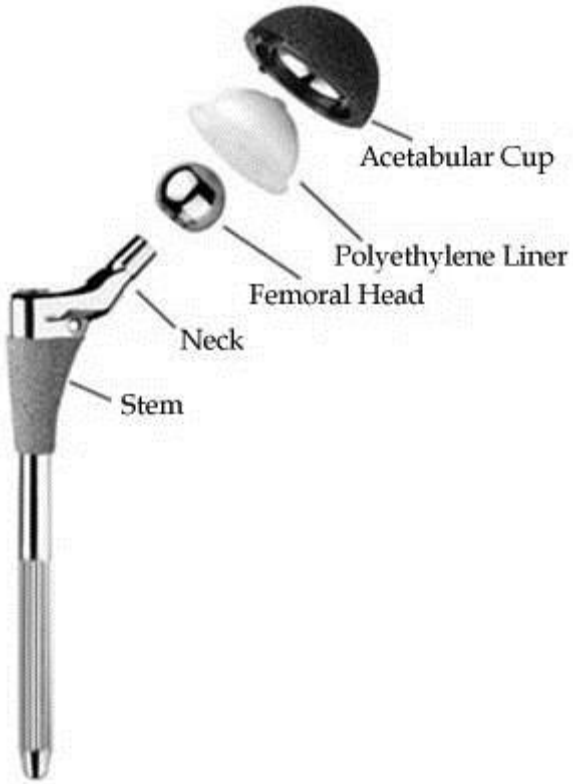

Fig. 7 The prosthesis of total hip replacement

Subsequent design development has led to cementless alternatives to the use of PMMA, hydroxyapatite coating was used for cementless design. When the acetabular component is monolithic, it is made of UHMWPE; when it is modular, it consists of a metallic shell and a UHMWPE insert. The metallic shell seeks to decrease the microdeformation of UHMWPE and to provide a porous surface for fixation of the cup. The metallic shell allows worn polyethylene liners to be exchanged and replacing after surgery.

As the development of bioceramics, other ceramic materials substitutions for some of the traditional materials for the THR as in table below. The most difficult substitution would be a replacement for the metallic femoral stem

Table: Current and potential engineered ceramics for the total hip replacement

Component	Material
Femoral Stem	Partially-stabilized zirconia(PSZ) or Ceramic-matrix-composites
Femoral Ball	Al_2O_3 or PSZ
Acetabular Cup	Al_2O_3 or PSZ
Cementless	Hydroxyapatite

Load bearing and motion of the prosthesis produces wear debris from the articulating surface and from the interfaces where there is micromotion, for example, stem-cement interface. Bone chip, cement chip, or broken porous coating are often entrapped in the articulating space and cause severe polyethylene wear (third – body wear). The principal source of wear under normal conditions is the UHMWPE bearing surface in the cup. Approximately 150000 particles are generated with each step and a large proportion of these particles are smaller than 1μm. cell from the immune system of the host, are able to identify the polyethylene particles as foreign and initiate a complex inflammatory response. This response may lead to rapid focal bone loss (osteolysis), bone resorption, losing and /or fracture of the bone. Recently, low-wear UHMWPE has been developed using a cross-linking of polyethylene molecular chains. Many attempts are try to modify the material properties of articulating materials to harden and improve the surface finish of the femoral head

The compressive load on the femoral ball makes any high density structural ceramic, such as alumina (Al_2O_3) and zirconia ceramics, a good candidate for that application. An especially attractive feature of ceramics for femoral heads is the typically low surface wear of structural ceramic